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SPACE SHUTTLE
Solid Rocket Motors
Thiokol Corporation

Qualification Test of the Ross Double Planetary Mixer Final Test Report

July 1993

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Qualification Test of the Ross Double Planetary Mixer
Final Test Report

July 1993

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ABSTRACT

This test report describes the qualification test of the Ross Double Planetary Mixer used to mix RTV silicone (Dow Corning 90-006-2) for the RSRM nozzle joints. Testing was completed 18 June 1993 in the M-113A Nozzle Fabrication Facility at Thiokol Corporation, Space Operations, Brigham City, Utah.

The Ross mixer provides better mixing and better control on temperature and humidity, resulting in better quality RTV and a longer usable pot life.

The test began on 3 May 1993 and was stopped due to operator error during the tensile strength and elongation testing. Specimens were ruined without gathering any useful data. A "no test" was declared, the problem was remedied, and the test was re-run with MSFC approval.

The test was run and all pass/fail criteria were met, most with a considerable margin. The Ross Double Planetary Mixer met all certification objectives and is recommended for immediate use for mixing RTV silicone for RSRM nozzle joints.

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INTRODUCTION

This test report describes the qualification test of the Ross Double Planetary Mixer used to mix room temperature vulcanized (RTV) silicone (Dow Corning 90-006-2) for the redesigned solid rocket motor (RSRM) nozzle joints. Testing was completed 18 June 1993 in the M-113A Nozzle Fabrication Facility at Thiokol Space Operations, Brigham City, Utah.

The RTV silicone is currently mixed in an open mix bowl which uses a single dough hook configuration for the mixing blades. The RTV silicone is mixed in a remote location far from the M-113A nozzle assembly building where the material is used. It is difficult to obtain a good silicone mix which has a controlled pot life because of the open mix bowl and the present mixer blade configuration. This condition has resulted in multiple discrepancy reports (DRs) and difficulty in obtaining a good joint backfill with the silicone. The silicone being mixed sometimes violates temperature requirements due to the remote location of the current mixer. The silicone is mixed in M-102 and transferred to an automobile in which it is transported to M-113A. In addition to possible violation of the temperature requirement, the transfer of silicone from M-102 to M-113A results in a loss of useable pot life.

This testing was conducted per CTP-0170A. This test showed that by using a vacuum mixer with a double planetary configuration in M-113A, there is a more uniform silicone mix with a much tighter control on pot life. The improved silicone mix ensures that the RTV silicone is capable of performing as well as or better than the RTV silicone produced by the current method.

1.1 TEST ARTICLE DESCRIPTION

The test article consisted of the Ross LDM-2 double planetary mixer. This mixer is equipped with bowl scraper blades and variable speed mixer blades that operate on the planetary mixing principle. The mixer blades rotate on individual axes while rotating about the mix bowl. The scraper blades are used to improve the homogeneity of the mix. During the mix process, the mixer also controls the vacuum pressure to less than 20 in. of Hg (gage).

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OBJECTIVES

Test objectives were derived from the Development and Verification (D&V) Plan (TWR-15723) Test Summary Sheet SRX-024. Test objectives satisfy contract end item (CEI) specification requirements (CPW1-3600A). CEI specification paragraphs are in parentheses after the applicable objective.

Qualification Objectives:

a. Certify that the Ross Double Planetary Mixer for preparing RTV silicone used in sealing RSRM nozzle joints yields a repeatable mix and meets specification requirements.

b. Certify that the mixing process will be accomplished using standards of workmanship that are consistent with the performance and reliability requirements (3.3.13).

Evaluation Objective:

a. Measure the viscosity of RTV silicone to evaluate repeatability.

2.1 PASS/FAIL CRITERIA

This qualification test shall be successful if the following criteria are met:

a. The minimum average Shore A hardness of an RTV silicone test specimen (Type 1 material) shall be 30 (STW7-2865, Para 3.4.3.1).
b. There shall be no discoloration in the RTV silicone after completion of the mixing cycle (ref Attachment).
c. The Ross mixer shall have a vacuum less than 20.0 in. Hg (gage) during the entire mixing cycle (ref Attachment).
d. The RTV silicone test specimen shall have a minimum tensile strength 325 psi (STW5-2813, Para 3.3).
e. The RTV silicone test specimen shall have a minimum elongation of 100 percent (STW5-2813, Para 3.3).
f. The RTV silicone shall have a temperature of 70° ± 10°F in the mix bowl during the mixing cycle.
g. The workmanship of the product is certified if the specification requirements are met (pass/fail criteria a, d, and e)

2.2 FLAG CRITERIA

The viscosity of the mix will be within a 3-sigma variation of the data collected in MPR-051.

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EXECUTIVE SUMMARY

3.1SUMMARY

Testing originally began 3 May 1993 to CTP-0170A. The nine batches of silicone were prepared and passed the discoloration, temperature, pressure, and Shore A Hardness tests. However, due to operator error, the elongation and tensile strength samples were ruined and a "no test" was declared (ref Attachment). After ensuring the same error would not occur again and getting MSFC approval to continue, the test was re-run.

The test was then successfully run with no operator error. All pass/fail criteria were met by a significant margin. Results from the testing are found in Table 1.

Table 1. Test Results

	4-lb Mixes			6-lb Mixes			8-lb Mixes		
	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
Pressure (in. Hg)	24	24	24	24	24	24	24	24	24
Temperature (°F)	68	68	70	70	70	70	71	71	66
Shore A No. 1	43	42	42	43	45	38	39	38	39
Shore A No. 2	42	41	42	42	43	40	38	39	38
Shore A No. 3	42	41	43	43	44	39	39	38	39
Strength No.1 (psi)	487	433	415	445	433	401	446	359	411
Strength No.2 (psi)	471	384	349	418	421	369	414	371	407
Strength No.3 (psi)	381	403	377	456	436	415	347	406	388
Average (psi)	446	403	380	440	430	395	403	379	402
Elongation No.1 (%)	156	131	126	144	151	143	151	121	138
Elongation No.2 (%)	134	131	113	132	141	120	138	124	128
Elongation No.3 (%)	138	122	124	131	120	135	120	129	127
Average (%)	142	130	123	146	137	133	136	125	131

The viscosity data were repeatable and showed a great improvement over the old mixing method. A discussion of the flag criteria is found in Section 6.

3.2CONCLUSIONS

Specification paragraph numbers are in parentheses.

Pass/Fail Criteria	Conclusions
a. The minimum average Shore A hardness of an RTV silicone test specimen (Type 1 material) shall be 30 (STW7-2865, Para 3.4.3.1).	*Certified.* The lowest Shore A hardness measurement for any of the samples was 38 (Table 1).
b. There shall be no discoloration in the RTV silicone after completion of the mixing cycle.	*Certified.* All nine batches of RTV silicone were prepared without any discoloration.
c. The Ross mixer shall have a vacuum less than 20.0 in. Hg (gage) during the entire mixing cycle.	*Certified.* All nine batches of RTV silicone were prepared with the pressure in the mix bowl remaining below 20 in. of Hg (Table 1).
d. The RTV silicone test specimen shall have a minimum tensile strength 325 psi (STW5-2813, Para 3.3).	*Certified.* The lowest tensile strength for any of the batches was 347 psi (Table 1).
e. The RTV silicone test specimen shall have a minimum elongation of 100 percent (STW5-2813, Para 3.3).	*Certified.* The lowest elongation for any of the batches was 113 percent (Table 1).

f. The RTV silicone shall have a temperature of 70° ± 10°F in the mix bowl during the mixing cycle.	*Certified.* In all nine batches, the temperature varied between 66° to 71°F (Table 1).
g. The workmanship of the product is certified if the specification requirements are met (pass/fail criteria a, d, and e)	*Certified.* Pass/fail criteria a, d, and e were met.
Flag Criterion The viscosity of the mix will be within a 3-sigma variation of the data collected in MPR-051.	The flag criterion as stated is a poor method to evaluate the viscosity data. The data from the viscosity test (Figures 7 through 9) are considered acceptable by Thiokol and MSFC. A discussion of the flag criterion is found in Section 6.

3.3 RECOMMENDATIONS

The Ross LDM-2 mixer passed all pass/fail criteria and the flag criterion. The mixer is recommended for immediate use for the preparation of RTV silicone.

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INSTRUMENTATION

The following instruments/measuring devices were used to validate the test:

a. Shore A hardness durometer that meets the requirements of ASTM D 2240 was used for this qualification test.
b. Monsanto T10 tensiometer was used for the tensile strength and elongation testing.
c. Pressure gage that is part of the Ross mixer was used for the vacuum measurements.
d. Brookfield HBT viscometer was used for the viscosity testing.

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PHOTOGRAPHY

Still color photographs of the test setup and test specimens were taken. Copies of the photographs (Series No. 133444) are available from the Photographic Services Department.

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RESULTS AND DISCUSSION

Testing of CTP-0170A originally began 3 May 1993 in the M-113A Nozzle Assembly Building. Testing went properly until the tensile strength and elongation testing began. Due to operator error, the specimens were ruined and forced a re-test. A memo was sent to MSFC to document the error (Attachment). Steps were taken to ensure the error would not occur again, and with MSFC approval, the test was re-run.

Nine batches of RTV silicone were prepared using the Ross LDM-2 mixer (Figure 1), three each of 4, 6, and 8 lb. A summary of the results of this testing is found in Table 1.

Figures 2 and 3 show the RTV base premix and the RTV silicone after mixing. At the beginning of the mix cycle, halfway throughout the mix, and at the end of mix, the vacuum pressure was measured (Table 1). In addition, the temperature was recorded during the mix cycle. For all batches, the temperature and pressure remained within the specification requirements, and thus passed the pass/fail criteria.

After the mixing process for each batch, the RTV was inspected to ensure there was no discoloration in the mix, i.e., catalyst properly mixed in the silicone.

Shore A hardness samples were prepared for each batch per STW7-2865C, Para. 4.2.1.1. For each batch, the test was conducted three times per STW7-2865C, Para 4.2.1.2. In all cases, the Shore A hardness of the RTV silicone passed the pass/fail criteria of 30 (Table 1).

Tensile strength and elongation measurements were made in accordance with ASTM D 412, using Die C at ambient (test bay) relative humidity (STW5-2813, Para 4.5.3.1.2). For each batch, three samples were pulled (Figures 4 and 5), and their elongation and tensile strength were recorded (Table 1). None of the samples tested violated the pass/fail criteria.

For demonstration purposes, the viscosity of each of the mixes were measured using a Brookfield digital viscometer (Figure 6). The viscosity was measured every half hour after mixing was complete. The results of the viscosity measurements are shown in Figures 7 through 9. The flag criterion was erroneously established because a 3-sigma limit cannot be established from the MPR-051 data because only one data point was taken for each set of parameters in MPR-051. However, the data have been discussed with MSFC and have been accepted. The intent of the flag criterion was to note whether the CTP data fell outside of a normal vacuum mix population for RTV. All of the data, with the possible exception of one 8-lb mix, showed a very consistent and flat viscosity versus time curve (Figure 9). The particular 8-lb mix still exhibited a much better viscosity curve than the old process and only exhibited unusual behavior outside the 2-hour pot life of the RTV.

ORIGINAL PAGE
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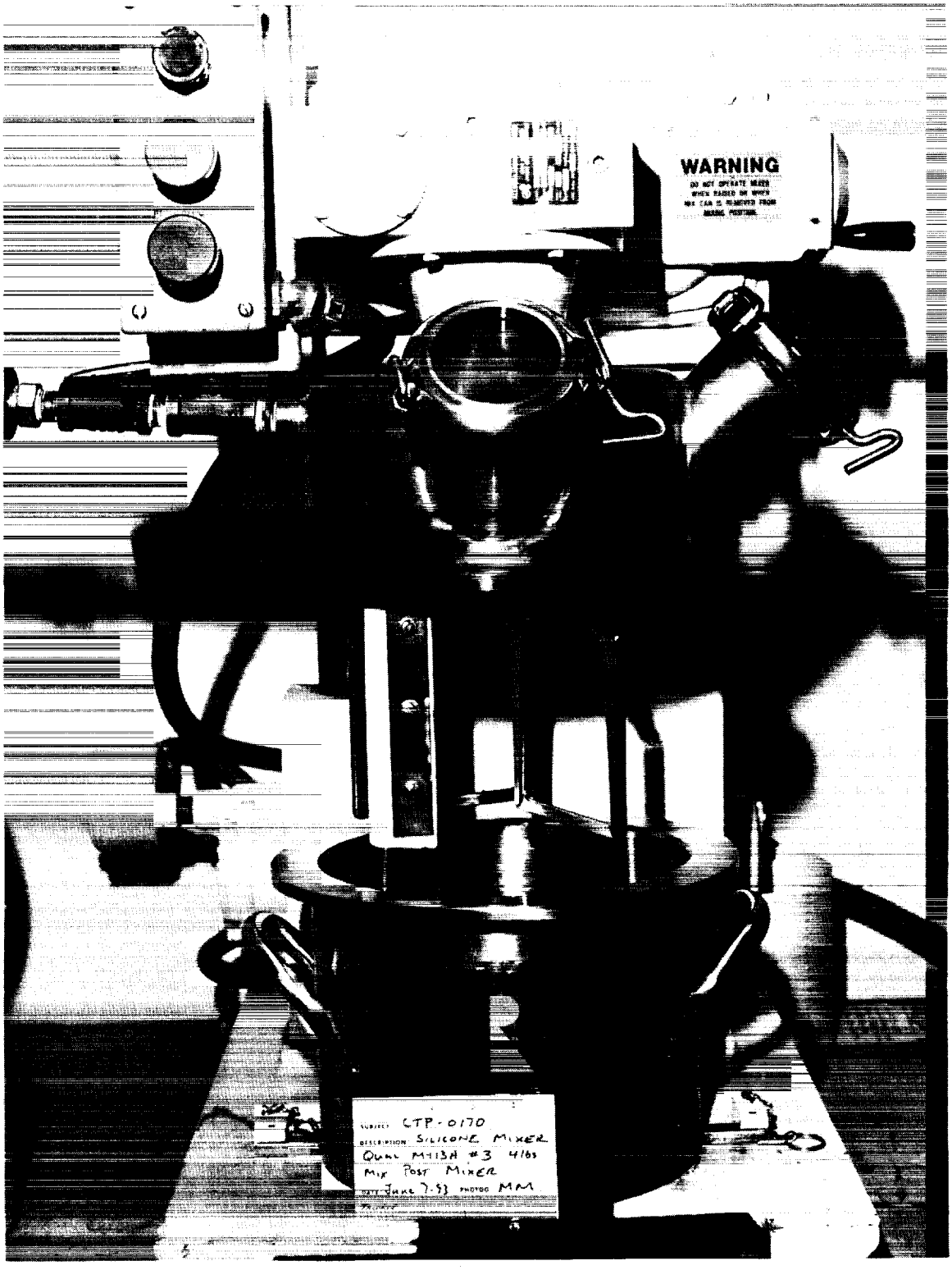

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Figure 1. Ross LDM-2 Mixer

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BLACK AND WHITE PHOTOGRAPH

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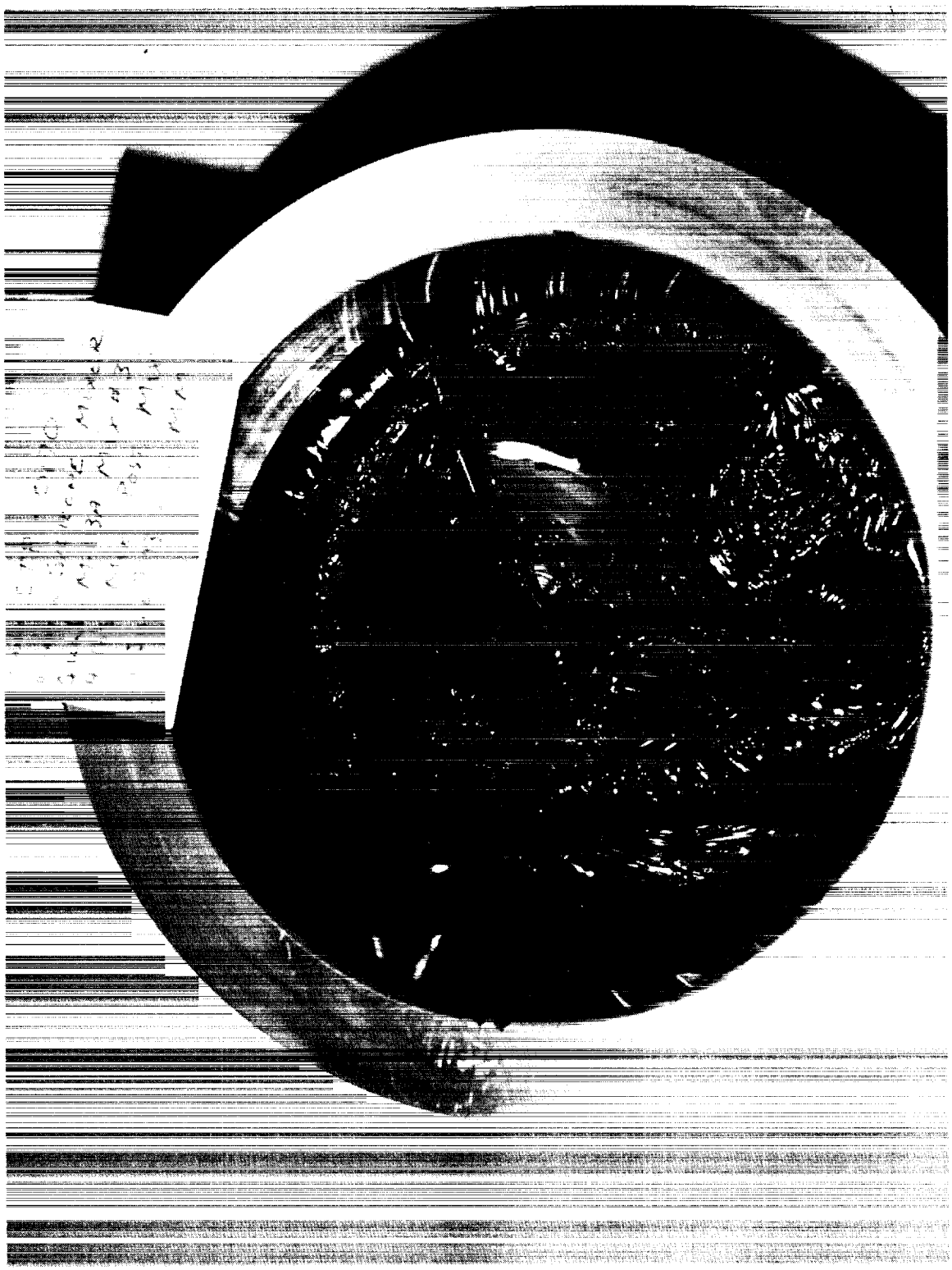
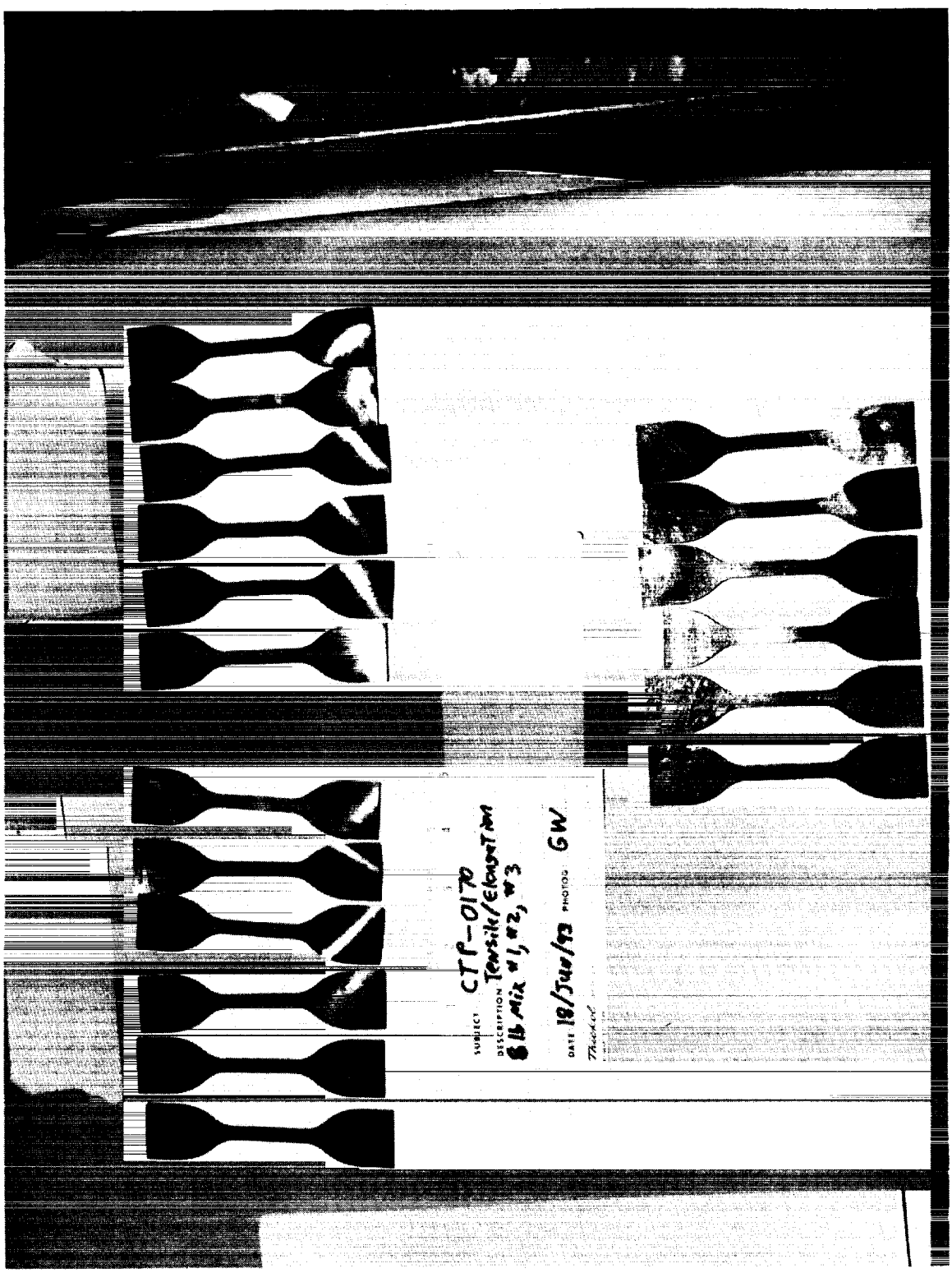
Figure 2. RTV 4-lb Mix Base Premix



N133370-4

Figure 3. RTV 4-lb Postmix



N133444-4

Figure 4. Tensile Strength and Elongation Samples

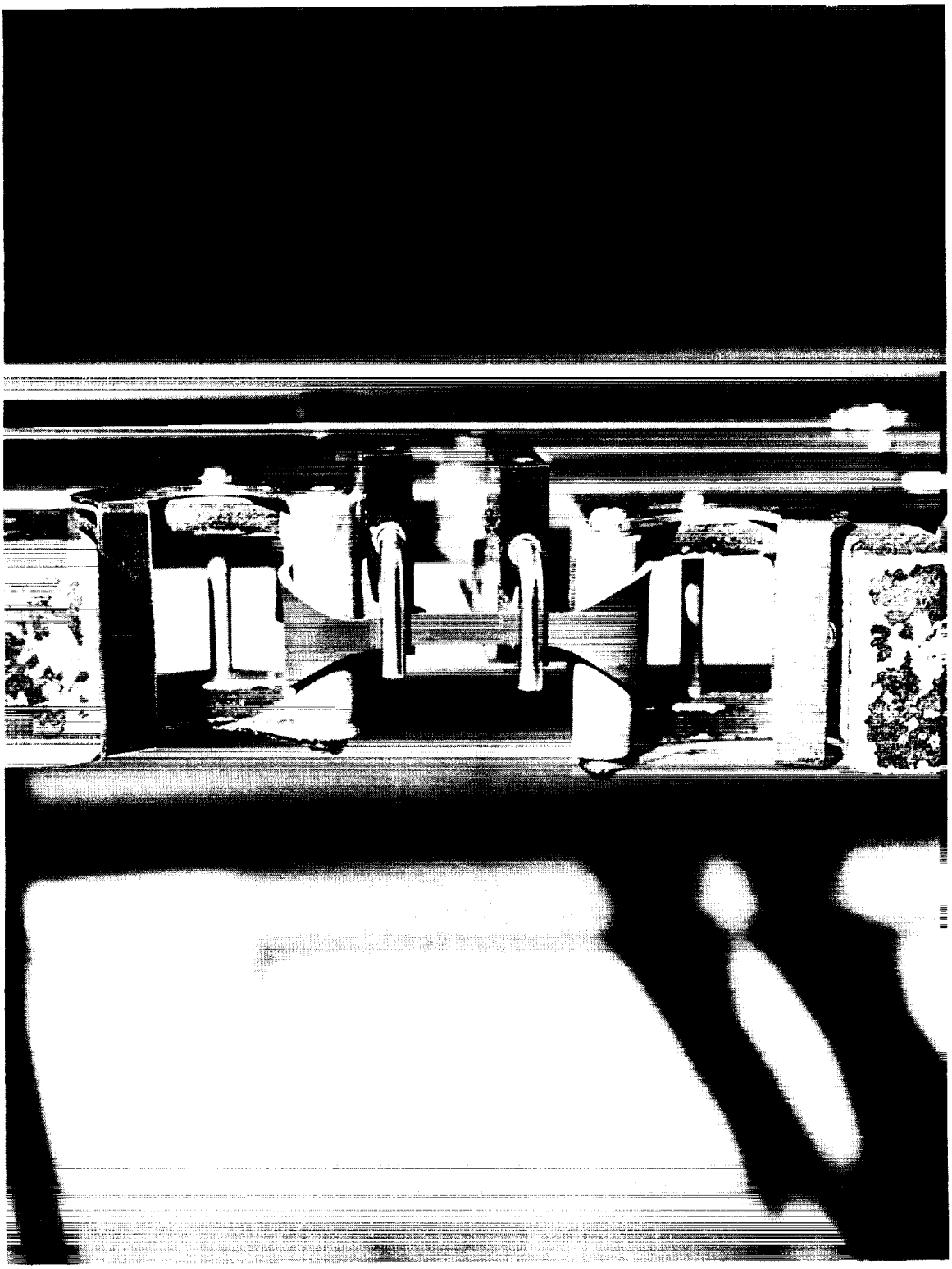


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Figure 5. Tensile Strength and Elongation Setup

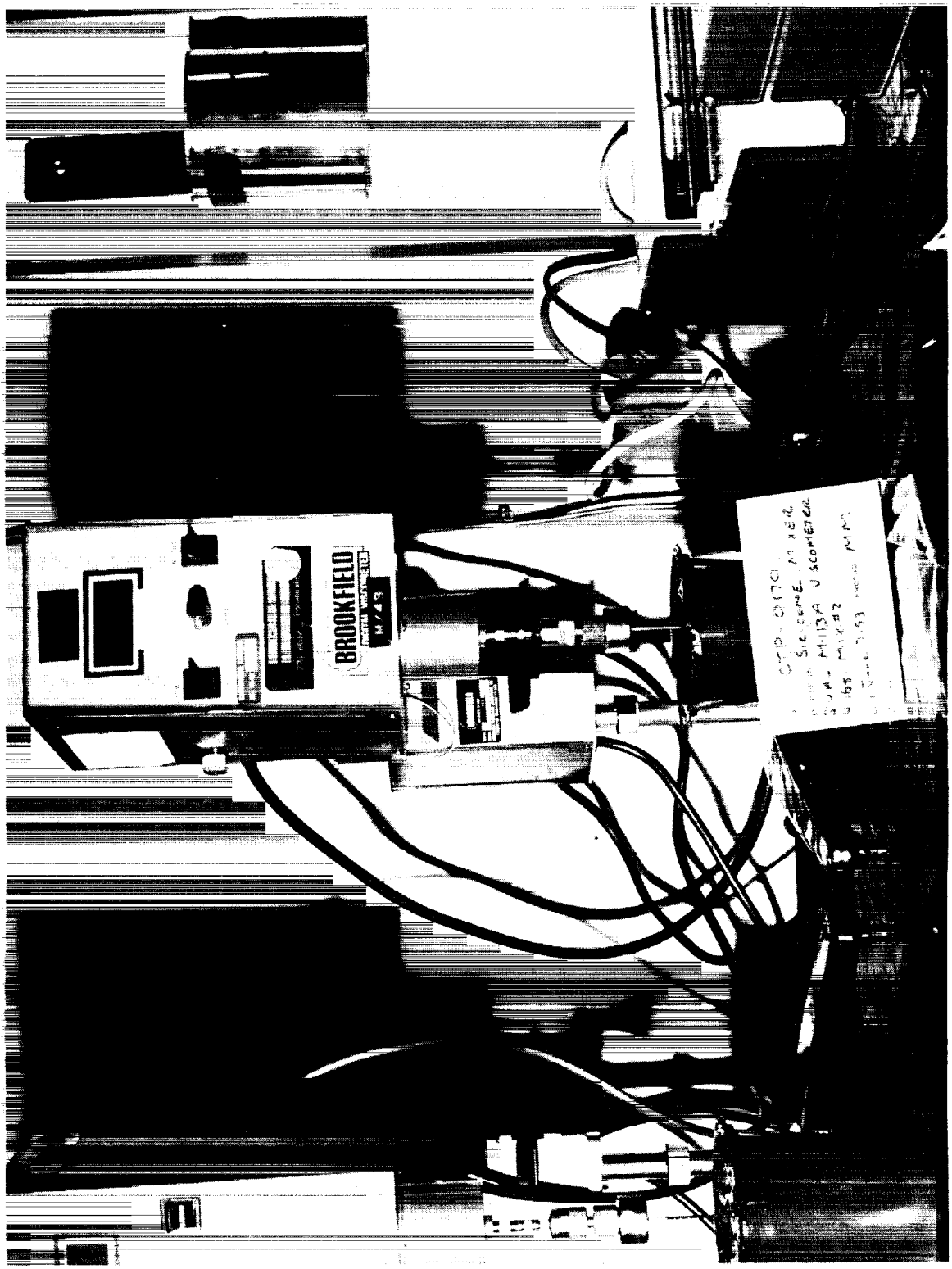

Figure 6. Viscometer

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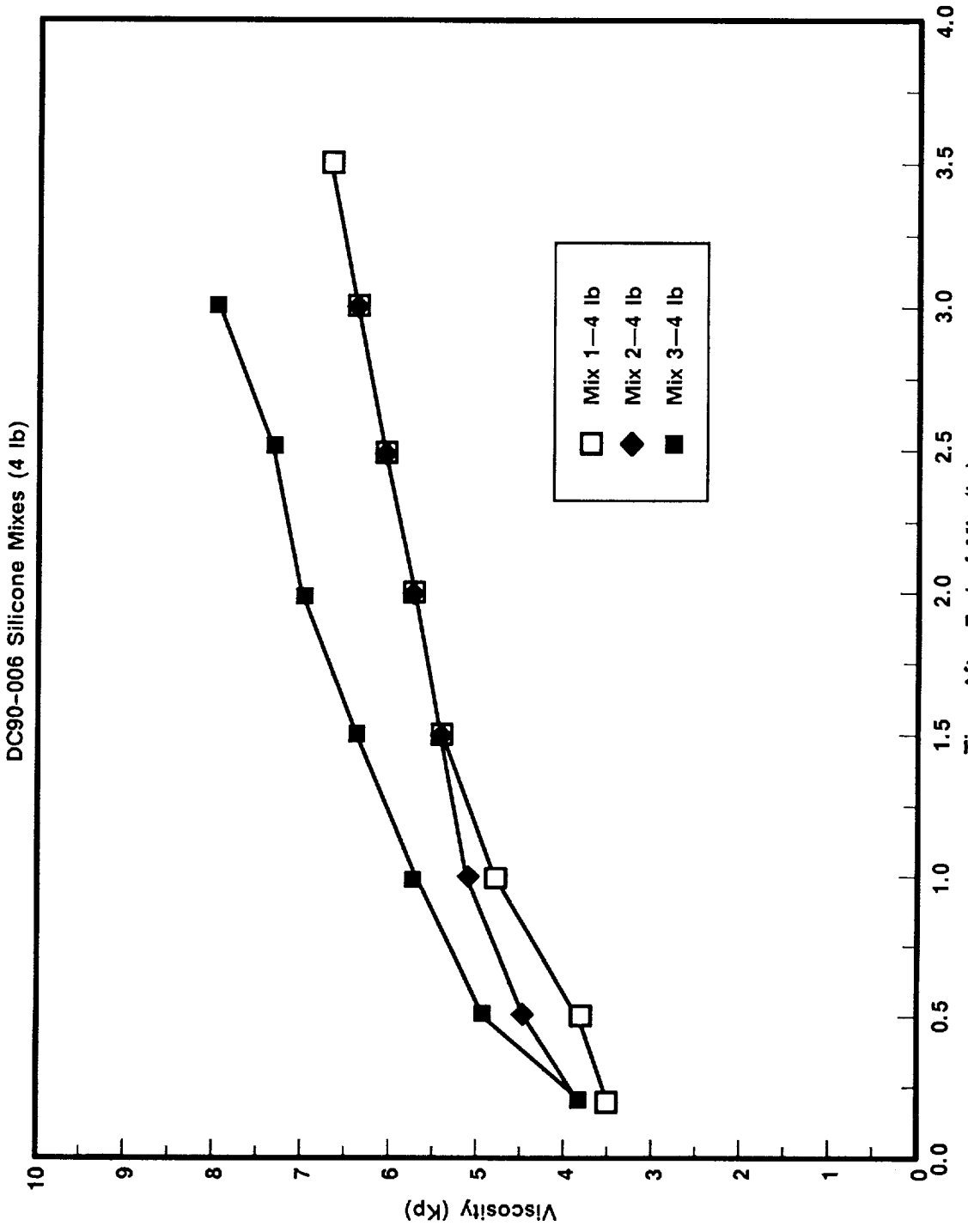

Figure 7. 4-lb Mix Viscosity Data

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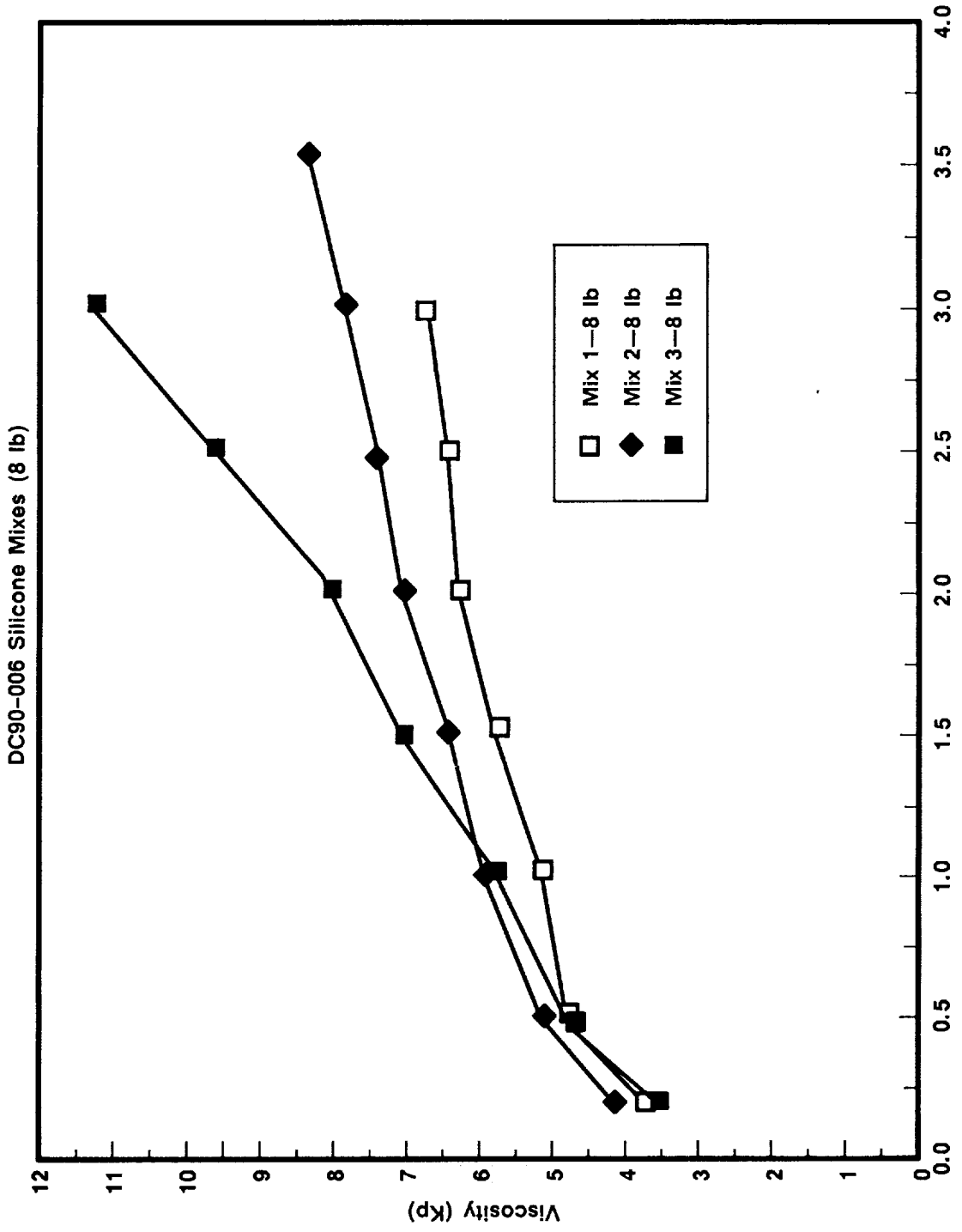

Figure 8. 6-lb Mix Viscosity Data

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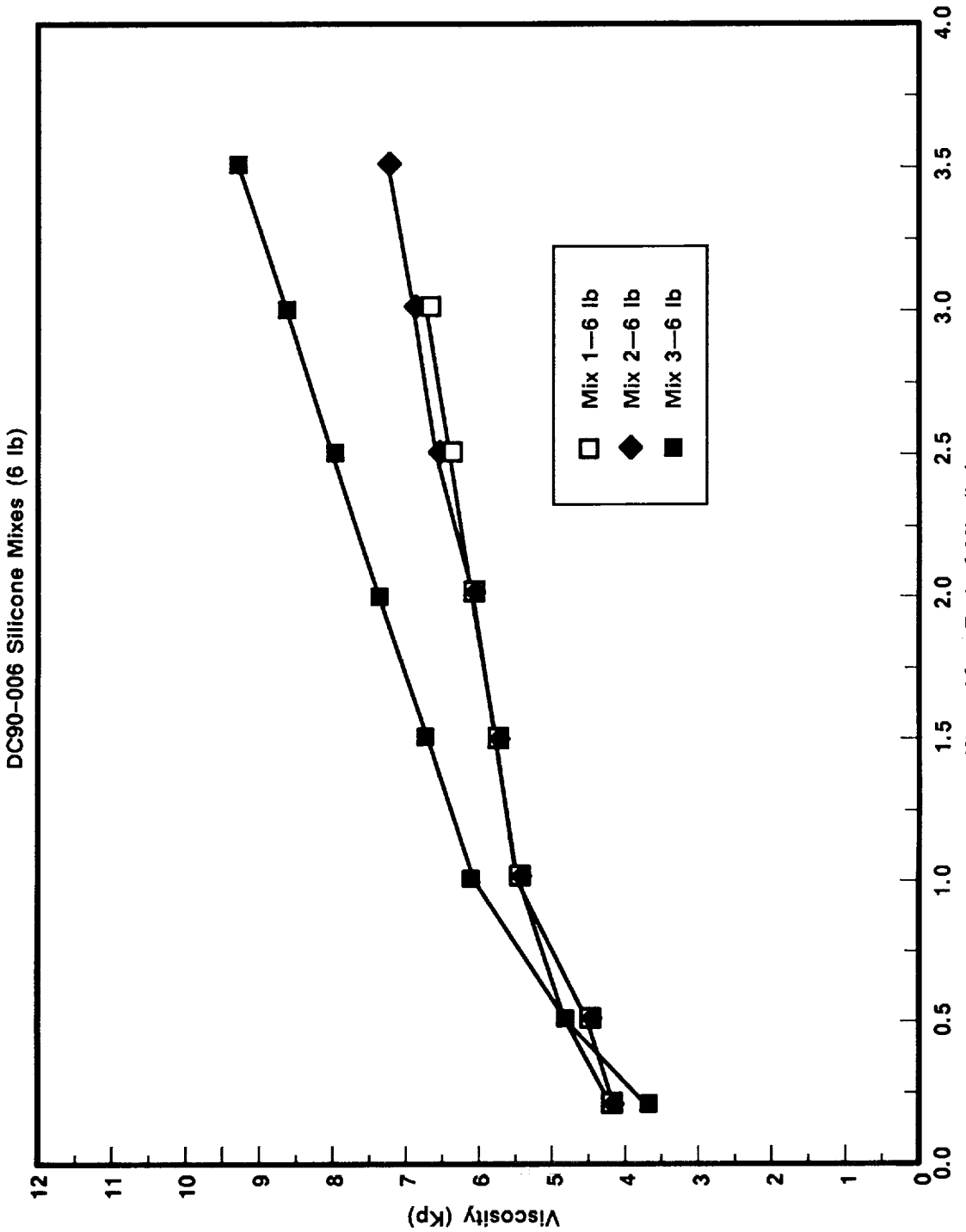

Figure 9. 8-lb Mix Viscosity Data

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APPLICABLE DOCUMENTS

Number	Title
STW5-2813	Sealant, Silicone, Room Temperature Vulcanizing
STW7-2865	Thermal Insulating Compound, Silicone Sealant and Silicone Rubber Potting Compound Material Test Specimens; Preparation, Testing and Acceptance of
ASTM D 2240	Indentation of Hardness of Rubber and Plastics by Means of a Durometer
ASTM D 412	Rubber Properties in Tension, Standard Test Methods for
CPW1-3600A	Prime Equipment Contract End Item Detail Specifications (CEI)
TWR-15723	Redesign D&V Plan
CTP-0170A	Qualification Test Plan for the Ross Double Planetary Mixer--Mixing RTV Silicone for the RSRM Nozzle Joints
MPR-051	Evaluation of RTV Mixer for Use in the M-113 Mix Room

Attachment

Thiokol CORPORATION

SPACE OPERATIONS

28 May 93
L713-FY93-M474

TO: Tom Williams, EE54/MSFC

CC: Jerry Walters, Roger Cook

FROM: Kurt Lueders (x5377)
Systems Planning and Interfaces

SUBJECT: "No Test" Declaration for the Ross LDM-2 Mixer Qualification Test (CTP-0170A)

CONTRACT NO. NAS8-38100

WBS NO. 4C102 10 05

ECS NO. SS3580

TEST NAME: Qualification Test Plan for the Ross Double Planetary Mixer - Mixing RTV Silicone for the RSRM Nozzle Joints

TEST LOCATION: Thiokol Building M-397, Promontory, Utah

TEST DESCRIPTION:

The purpose of CTP-0170 is to certify the Ross Double Planetary LDM-2 Mixer for mixing RTV silicone for the RSRM nozzle joints. The Ross LDM-2 mixer is equipped with bowl scraper blades and variable speed mixer blades that operate on the planetary mixing principle. The mixer blades rotate on individual axes while rotating about the mix bowl. The scraper blades are used to improve the homogeneity of the mix.

During the operation of the mixer, a vacuum of less than 20.0 inches of Hg (gage) is maintained. Evaluation testing (MPR-051, TWR-63477) of the Ross mixer and the mixing process showed that vacuum mixing increases the pot-life of RTV silicone to a minimum of three hours, almost double in comparison to non-vacuum mixing. Tensile adhesion strength is also increased when vacuum mixing.

The Ross mixer shall be qualified by using it to produce nine batches of RTV silicone. These batches shall be three each of four, six, and eight pounds. During the mixing cycle, pressure measurements shall be taken to ensure that a vacuum is maintained. After mixing is complete the RTV silicone shall be visually inspected for discolorations. Samples shall be taken from each batch to conduct Shore A hardness, tensile strength, and elongation testing.

OBJECTIVES: The objectives of Test Plan CTP-0170 were as follows:

A. Certify the Ross Double Planetary Mixer for preparing RTV silicone used in sealing RSRM nozzle joints.

B. Certify that the mixing process will be accomplished using standards of workmanship which are consistent with the performance and reliability requirements. (3.3.13)

Evaluation Objectives

C. Measure the viscosity of RTV silicone to evaluate repeatability.

PASS/FAIL CRITERIA

This qualification test shall be successful if the following criteria are met.

A. The minimum average Shore A hardness of an RTV silicone test specimen (Type 1 material) shall be 30 (STW7-2865, para. 3.4.3.1).

B. There shall be no discoloration in the RTV silicone after completion of the mixing cycle (Reference Attachment 1).

C. The Ross mixer shall have a vacuum less than 20.0 inches Hg (gage) during the entire mixing cycle (Reference Attachment 1).

D. The RTV silicone test specimen shall have a minimum tensile strength 325 psi (STW5-2813 para. 3.3).

E. The RTV silicone test specimen shall have a minimum elongation of 100% (STW5-2813 para. 3.3).

F. The RTV silicone shall have a temperature of 70 ± 10°F in the mix bowl during the mixing cycle.

G. The workmanship of the product is certified if the specification requirements are met (pass/fail criteria A, D, and E)

FLAG CRITERIA

A. The viscosity of the mix will be within a 3 sigma variation of the data collected in MPR-051.

INITIAL ENGINEERING ASSESSMENT:

The testing began on 10 May 1993. The nine batches of RTV silicone were mixed and vacuum pressure remained less than 20 inches Hg throughout all mixing. All batches were visually inspected for unmixed catalyst, and all batches passed inspection. Viscosity measurements were made for each batch, and all measurements fell within the 3 sigma limit called out in the flag criteria.

Samples were prepared for the Shore A hardness test per STW7-2865C para. 4.2.1.2. All samples were above 30, the limit spelled out in the Pass/Fail Criteria.

Samples were then prepared for the tensile strength and elongation measurements. STW5-2813 para. 4.5.3.1.2, the specification for conducting tensile and elongation testing, was followed with the following two exceptions: 1) The samples were prepared with a die larger than die C, the die called out in the specification, and 2) Serrated grips were used on the tensiometer when testing the specimens instead of flat grips.

The serrated grips caused a greater stress concentration at the ends of the specimen instead of the gauge area, which would be the point of failure in a successful tensile strength test. This stress concentration caused 50 of the 56 specimens tested to fail at the ends of the specimen. Because the improper die was used, even the six that failed in the gauge area are unusable data points.

Because the test plan was not properly followed, the Pass/Fail Criteria in CTP-0170A are not applicable and therefore, a test failure did not occur. Thus, the result of this test effort is a No Test. It is recommended that the test be re-run after the proper measures have been implemented to ensure such a problem will not occur again in the future.

Kurt Lueders

K.F. Lueders

Concurrence:

D. E. Campbell, Supervisor
Systems Planning and Interfaces

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